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QUESTIONS ON GEIKIE'S ELEMENTARY PHYSICAL GEOGRAPHY.

SCHOOL CLASS BOOKS

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QUESTIONS

ON

GEIKIE'S ELEMENTARY

PHYSICAL GEOGRAPHY.

FOR THE USE OF SCHOOLS.

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1885.

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PREFACE.

With the view of aiding Teachers in the use of the *Elementary Lessons in Physical Geography*, I have prepared the following series of Questions. It is obviously desirable that as frequently as possible the question should be so framed that the answer cannot be given in the mere words of the Lesson, but requires that the meaning of the paragraph to which it refers be first clearly apprehended. Much advantage will accrue from copious exercises upon the Maps, of which enlarged copies for use as diagrams will be found serviceable. Advantage should likewise be taken of every opportunity of illustration from familiar or easily observable phenomena. Examples are given in the Lessons to show how this may be done (see, for instance, Lesson VI.). This method, to be adopted in every subject where it is admissible, may be carried into effect in oral teaching in a way which cannot of course

be attempted in a systematic class-book. Thus, daily examples of changes of weather, clouds, rainfall, storms, &c., should be sedulously made use of. Every local illustration also of any characteristic form of the surface of the land—plain, hill, mountain, valley, ravine, river, lake, spring, woodland, cornfield—whatever it may be, should be connected by the teacher with some of the great agencies by which that surface has been moulded. In this class-book, intended as it is for general use in any country, the introduction of many local illustrations of this kind was avoided. But opportunity has been taken to insert a few examples from different parts of the globe, sufficient, it is hoped, to guide both teacher and pupil towards the observation and use of others. In such practical instruction a skilful teacher, travelling far beyond the limits of the class-book, will arouse in his scholars a hearty interest in the subject, a sympathy with himself in the study of nature, and a growing desire for further knowledge.

A. G.

September, 1877.

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QUESTIONS

ON

GEIKIE'S

ELEMENTARY PHYSICAL GEOGRAPHY.

CHAPTER I.

THE EARTH AS A PLANET.

Lesson I.—The Earth's Form.

1, 2. What branch of science specially deals with the nature of the Earth?

How may the Earth be proved to be a globe?

3. What must be the appearance of the Earth as seen from a distance of a few million of miles? from the sun? and from the nearest fixed star?

4. What is to be observed regarding the spherical form of the Earth?

What are the Earth's Axis, North Pole, South Pole, and Equator?

LESSON II.—THE EARTH'S MOTIONS.

1. Name the chief movements of the Earth.

2. What is Rotation?

Within what period is this movement effected?

How does rotation give rise to day and night?

What is the real direction in which the earth rotates?

3. Why does the rate of motion vary for different parts of the earth's surface?

What is the rate at the equator and poles respectively?

4. What keeps bodies from being whirled off from the surface of the rotating globe?

5. What is meant by the Revolution of the Earth?

Within what period is a complete revolution effected?

What is the earth's orbit?

What is the mean distance of the earth from the sun?

What is the average rate at which the earth revolves, and how is this computed?

6. What arrangement would give rise to equal day and night all the year?

Why are the days and nights of unequal lengths?

What is the amount of inclination of the earth's axis to the plane of the orbit?

7. When are day and night of equal length over all the globe, and why is this?

Why is a summer day longer in England

than in India? and a winter day longer in London than in Scandinavia?

8. Why does the length of the day increase towards one pole, while it diminishes towards the other?

9. What causes the phenomena of the Seasons?

How are these phenomena familiarly manifested?

10. What are the Northern and Southern Hemispheres?

What is the position of the earth during summer in the Northern Hemisphere?

Why is summer warmer than winter?

What is the condition of the Southern Hemisphere when it is midwinter in the Northern?

11. Why should the contrast between summer and winter be most marked at the poles?

What are the Tropics?

What determines the position of the Tropics?

Make a diagram to show the lines of the Tropics, and of the Arctic and Antarctic circles, and to explain why these lines are drawn round the globe.

What is the apparent position of the sun at the Tropic of Cancer about the 22nd of June?

What is the apparent position of the sun at the equator about the September equinox?

What is the apparent position of the sun at the Tropic of Capricorn about the 22nd of December?

12. How often in the year is the sun vertical between the Tropics?

What change in the seasons accompanies this vertical position of the sun?

What interferes with the regularity and uniformity of this arrangement?

LESSON III.—THE EARTH AND THE SUN.

1. Why should sun-worship have been a prevalent form of idolatry?

4. What is observed regarding the temperature of the water which rises from deep borings?

What is noticed about the temperature of deep mines and of many springs?

What are volcanoes?

5. What conclusions have been drawn from these facts?

6. Why is the earth believed not to be a self-luminous body?

Why does the earth shine like the moon?

7. What is the moon?

8. Describe the appearance of the hills around Naples.

9. Describe the surface of the moon.

What have astronomers determined regarding the size and numbers of the lunar volcanoes?

What inference as to the former history of the moon may be drawn from the abundance of these volcanoes?

10. Has any evidence been found that the volcanoes of the moon are still active?

11. Why must we conclude that the earth is cooling?

12. What may have been the condition of the earth a hundred millions of years ago?

How may the present oblately spheroidal form of the earth be connected with a former liquid condition?

13. What is the fundamental difference between the shine of the earth, and moon, and the light of the sun?

Whence does the heat of the sun proceed?

What resemblance has been observed between the chemical composition of the sun and the earth? and how has this been detected?

14. What analogy exists between the earth and the sun as regards rotation, and how has this been observed?

15. What are planets?

In what respects do they resemble the earth?

16. What is meant by the Solar System?

17. Explain what is intended by the Nebular Theory.

18. How does the Nebular Theory account for the present form and internal heat of the earth?

LESSON IV.—MEASUREMENT AND MAPPING OF THE EARTH'S SURFACE.

1. What methods have been used for ascertaining the relative positions and distances of places on the earth's surface?

2. In what way does the position of places on the earth's surface with respect to the sun vary from hour to hour?

3. How many degrees of the terrestrial

circumference does a place pass over in an hour?

How many degrees must intervene between two places which have their noon at an interval of three hours?

4. What various ways have been employed for determining how far one place lies to the east or west of another?

5. Which is the most accurate method of observation?

What is meant by "finding the longitude" of a place?

6. What are meridians of longitude?

Whence are the meridians counted in England?

What is to be observed regarding the time of day or night for all places situated on the same meridian?

What is meant by East Longitude and West Longitude?

How is the longitude of a place expressed? Give an example.

7. What is the value in time of one degree of longitude?

Why does a watch seem to be losing time as it is carried eastward, and to be gaining as it is carried westward?

8. Show how strikingly differences of longitude and time are illustrated by the electric telegraph.

9. What is meant by "finding the latitude"?

Why are degrees of latitude uniformly counted from the same starting point?

10. What is the Celestial Pole?

What is the Celestial Equator?

What is meant by the Zenith?

How are the Celestial Pole and Equator employed in finding the latitude?

11. What are parallels of latitude?

Whence are they counted and how are they divided?

12. How are degrees of latitude expressed?

What is the latitude of the poles?

Explain the expressions, "low latitudes" and "nigh latitudes?"

13. Why is further measurement required before the absolute distances of remote places on the earth's surface, and the area of continents and oceans can be determined?

14. Why does the distance of the lines of the meridians from each other vary according to latitude?

What is meant by the measurement of a degree of the meridian? why is it necessary?

15. Give the length of a degree in India and in Sweden.

How does the form of the earth vary from that of a perfect globe?

16. Give the length of the polar diameter.

What is the mean equatorial diameter?

State the extent of the terrestrial compression at each pole.

How long would an express railway-train, travelling without stopping at a rate of thirty miles an hour, take to go round the earth at the equator? and along the axis from pole to pole?

17. Mention the relative proportions between the size of the earth and that of other members of the Solar System.

How many globes as large as ours could be contained within the mass of the sun?

Give the distances of the Earth, and the planets Mercury and Neptune, from the sun.

18. What is a Map?

19. Describe the process of triangulation?

Lesson V.—A General View of the Earth.

2. In what proportions are land and sea distributed over the surface of the globe?

3. In which hemisphere does the water predominate?

Where does the centre of the general mass of land lie?

What is the position of New Zealand with respect to the seas of the globe?

4. What is meant by the Old World and the New World?

5. What is the most obvious contrast between the distribution of the land and sea in the different quarters of the globe?

6. What are Oceans?

How are their limits marked?

State generally the area occupied by the Pacific and Atlantic Oceans.

What are the Arctic and Antarctic Oceans?

8. What is meant by the sea-level?

What use is made of the sea-level in measuring the heights and hollows of the earth's surface?

Mention some instances of slight differences between the sea level of different oceans.

9. What are Continents?

Describe the grouping of the Continents.

10. What general feature is noticeable about the shape of the Continents? Give illustrations.

11. What are inlets, islands, and peninsulas?

What is an isthmus?

Show how much more broken up is the land than the sea.

12. Contrast the surface of the sea with that of the land.

13. Show briefly how the position and form of the land may affect currents of the sea and of the air.

14. What are volcanoes? How are they generally distributed?

What are earthquakes?

How does the existence of volcanoes and earthquakes bear upon the form of the surface of the land?

CHAPTER II.

THE AIR.

LESSON VI.—THE COMPOSITION OF THE AIR.

1. WHAT is the Atmosphere?

2. Of what does Air mainly consist? How may this be proved?

In what proportions do the gases exist in air?

3. Mention other ingredients of the air.

4. How may the presence of solid particles in the air be shown?

5. What are these solid particles?

How may diseases be propagated by them?

6. How are the solid particles affected by rain?

Mention what is obtained when a little rain-water collected in a town is evaporated to dryness.

Show how this action of rain is beneficial.

7. Mention three additional important ingredients of the air.

What is ozone believed to be? when is it specially noticeable?

How does it benefically affect the air?

Where is it most and least abundant?

8. What happens when a piece of coal or a candle is burnt out?

9. What is carbon? what part does it play in the structure of plants and animals?

What is coal?

What becomes of the carbon when a piece of coal or a candle is burnt?

10. What constitutes combustion?

Why does a flame drop down and finally go out, if the air is excluded from it?

How does carbonic acid gas arise from the combustion of organic substances?

11. How is carbonic acid gas supplied to the air by the breathing of animals?

12. What effect have living plants upon the carbonic acid of the air?

What happens to the carbon in the decaying bodies of plants and animals?

13. Where is carbonic acid gas supplied from the ground?

Summarize the various sources from which the air obtains carbonic acid.

14. What is the proportion of carbonic acid gas in ordinary pure air?

Show how important this small proportion is.

15. What is the aqueous-vapour of the air?

What becomes of water which is boiled?

How may invisible vapour be changed into visible water?

On what does the capacity of the air to retain vapour depend?

16, 17. Show how it may be proved that we are each breathing water-vapour into the air.

18. Give some familiar illustrations of the constant presence of water-vapour in the air.

19. Show how the importance of the water-vapour of the air may be illustrated.

20. Is the quantity of vapour in the air constant?

What does this quantity amount to on an average?

LESSON VII.—THE HEIGHT OF THE AIR.

1. Why does the earth's rapid rotation create no commotion in the atmosphere?

2. Prove that there must be an outer limit to the atmosphere.

What is supposed to lie beyond the limits of the atmosphere?

3, 4. What is the nature of meteors?

Why do they glow and disappear?

What limit do they indicate for the height of the atmosphere, and how is this measured?

5. Why cannot we breathe so freely at great heights in the air?

LESSON VIII.—THE PRESSURE OF THE AIR.

1. What is meant by atmospheric pressure?

2. How may the pressure of the air be shown?

How much does this pressure amount to?

What is the amount of the pressure upon our bodies?

Why does not this pressure incommode us?

What would follow if the air inside our bodies were withdrawn?

3. How may the pressure of the atmosphere be used in ascertaining the heights of mountains?

4. What is a Barometer?

What is the principle of its construction?

5. How is the barometer used in measuring heights?

6. Is the pressure of the air always the same at the same level?

How are we made sensible of changes of pressure?

How do such changes affect the barometer?

7. What change in the air is indicated when the mercury in the barometer has fallen an inch during a single night?

8. How is the barometer tube divided?

What is the average height of the mercury column at the sea-level?

Mention a region where the height of the mercury is permanently below the average and another where it is permanently above it.

What is meant by the terms "low pressure" and "high pressure"?

9. Why is it important to watch carefully the daily and hourly variations in atmospheric pressure?

To what causes have these variations been assigned?

10. What happens when air is heated, and when it is cooled?

How does the heating of the air influence atmospheric pressure?

12. Describe an experiment to show the difference between the weight of water-vapour and perfectly dry air.

13. At a temperature of 50° Fahr. what is the difference between the weight of water-vapour and perfectly dry air?

Is water vapour at all ordinary atmospheric temperatures always lighter than air?

14. Describe an experiment to show the difference in weight between three equal quantities of air saturated with water-vapour at temperatures of 32°, 50°, and 80° respectively.

15. What conclusion is to be drawn from this experiment?

What effect is produced on the pressure of the air by the abundant vapour which is constantly rising into the atmosphere?

16. Is the quantity of vapour in the air constant?

What effects on the pressure of the air must be produced by the addition and removal of water-vapour?

How are these effects shown by the barometer?

Are these oscillations of atmospheric pressure rapid or slow?

17. Is it known how the enormous changes in the volume of vapour in the air are produced?

How do they manifest themselves in sensible effects upon the air?

18. To what influence are all movements of the air traceable?

19. What are Isobars or Isobaric lines?

What is the general distribution of atmospheric pressure over the globe?

Where are the areas of high and low pressure most continuous?

What influence tends to break up their continuity?

Compare Plates II. and III. and point out some examples of the influence of summer and winter upon the position of the areas of high and low pressure.

Lesson IX.—The Temperature of the Air.

1. Are the fluctuations in the temperature of the air always sensible?

What is a Thermometer?

What is the principle of its construction?

What is the distinction of Fahrenheit's thermometer scale?

Give the place on Fahrenheit's scale of the following temperatures: — the freezing-point of fresh-water; summer-heat in England; the boiling-point of water.

What is meant by low temperature and high temperature?

2. What use has been made of the Thermometer in investigating the temperature of the globe?

What are Isotherms or Isothermal lines?

How are Isothermal lines named?

Do the temperatures indicated by these Isothermal lines depend upon the heat of the earth itself?

What would happen if the surface of the earth received no more heat than is carried outward from the heated interior?

5. Whence then does our supply of heat come?

Why is a clear night cold?

On what do the contrasts in temperature of different parts of the earth's surface depend?

6. What effect have the heat-rays of the sun upon the air as they pass through it?

How is the air warmed?

7. How is the heating power of the sun's rays affected by the angle at which they reach the surface?

Where is this power greatest? where least?

Why is the sun's heat less felt at morning and evening than at noon?

8. Which portions of the earth's surface have the highest temperature, and why?

Which are the cold regions of the earth, and why are they cold?

What conclusion is to be drawn from these facts as to the causes which govern the distribution of temperature over the globe?

9. What might we expect to be the normal relation of the temperature of the various latitudes between the equator and the pole?

10. Does this relation always hold?

How are the summers and winters in England and in Labrador contrasted?

11. How are Isothermal lines related to parallels of latitude?

12. Where are these lines most regular, and where do their greatest deflections occur?

What general fact is thus shown regarding the distribution of temperature?

13. Describe the course of the Isotherm of 50° Fahr. from the east coast of England to the shores of the United States.

14. What determines the divergence of the Isotherms from the parallels of latitude?

15. What is the influence of the land and of the sea respectively upon the distribution of temperature?

Illustrate the influence of the sea by describing briefly the effects of a warm and of a cold current upon temperature.

16. What arrangement of land on the surface of the globe would raise the temperature, and what arrangement would depress it? Show how this is indicated by the course of the Isothermal lines?

17. Do two places which have the same mean annual temperature enjoy consequently the same climate?

Give an example to show that great differences in summer and winter temperatures may be combined with similarity of mean annual temperature.

18. How should the climates of two places be compared?

19. What is the second general conclusion to be drawn from these facts regarding the distribution of temperature?

20. What difference is to be remarked between the temperature of the air on hill-tops and that of the air on the plains below?

How is this difference shown in Britain?

How does it appear among the Alps and other lofty mountains?

What is the rate at which the change of temperature with elevation appears usually to take place?

Show how in tropical regions increased eleva-

tion above the sea is equivalent, as regards temperature, to distance from the equator.

What is the third general deduction as to the distribution of temperature, warranted by these facts?

21. Does the constant heat received from the sun make the earth permanently warmer?

What relation has been traced between rainy or stormy seasons and those periods when the spots on the sun are most numerous?

Does this relation suggest any possible variation in the quantity of heat received by the earth from the sun?

22. When is radiation most observable?

How are the effects of radiation most readily sensible?

LESSON X.—THE MOISTURE OF THE AIR.

2. From what sources is the moisture of the air derived?

Why do pools of water diminish and disappear?

3. When does the air cease to abstract vapour?

How is the point of saturation affected by temperature?

What influence has wind upon evaporation?

4. When does evaporation chiefly take place?

5. What is the estimated amount of water annually condensed out of the atmosphere on the earth's surface?

How do rivers indicate the vastness of this amount?

6. What becomes of the water which is continually passing by evaporation into the air?

7. In what relation do the processes of evaporation and condensation stand to each other?

Referring to what has been learnt in Lesson VIII. indicate briefly how evaporation and condensation must affect the pressure and consequently the movements of the air.

8. Is the air often completely saturated with or ever entirely devoid of vapour?

9. What effect has the vapour of the air upon the surface temperature of the earth?

What would happen if the vapour were removed from the air?

10. What effect has evaporation upon the temperature of the evaporating surface?

Give some familiar examples of this effect?

What becomes of the heat so abstracted?

11. What happens to this abstracted heat during condensation?

How much heat is computed to be liberated by the condensation of a pound of water from the state of vapour?

What must be the general influence of condensation upon the temperature of the air?

12. What various forms does water assume on condensation?

13. Mention the three conditions under which the substance called water exists.

Within what range of temperature does this substance ordinarily assume a liquid form?

What temperatures determine the formation of vapour?

At what temperature does water become solid, and what name is then given to it?

What is meant by freezing?

Explain the meaning of the three terms, *boiling-point, freezing-point, dew-point.*

14. What is Dew?

When is dew formed, and when is it commonly wanting?

Explain the formation of dew.

Why are some surfaces, such as those of leaves, covered more copiously with dew than others such as stones and earth?

Is the temperature of the dew point always the same? (Arts. 12 and 15.)

15. In what manner does the formation of dew affect the temperature of the air?

When the temperature sinks to 32° Fahr. what becomes of the dew?

Explain the influence of clouds upon the formation of dew.

16. How is mist or fog formed?

Explain the formation of evening fog over a river.

Show why a mountain often has its slopes wrapped in mist.

17. What is a cloud?

How are clouds formed?

Show how clouds often indicate the existence of different currents in the atmosphere.

19. What happens when a mass of warm moist air rises high above the surface of the earth?

Show how the general form of a cloud may remain, though there may be ceaseless movement of its vapour.

20. Explain the familiar formation and disappearance of large masses of white cloud in calm summer weather.

21. Show how clouds may be formed and dissipated by currents of the air.

Explain why ascending clouds increase and descending clouds decrease in size.

To what cause must the continual changes in the size, shape, and movements of the clouds be assigned?

22. What rate of motion has been observed among the clouds on a breezy day?

23. Explain why a cloud should remain persistently on a hill-top even when a high wind is blowing.

24. How are clouds useful in regard to changes of weather?

25. What is the chief work done by clouds in the general economy of the globe?

26. In what form is the largest part of the vapour of the air condensed upon the earth?

How is rain formed?

27. Give examples of different ways in which rain may be condensed.

28. Over what regions of the earth's surface is the fall of rain greatest, and why?

29. What is the relative influence of sea and land on the rainfall?

What difference is observed between the amount of rain near the sea and far inland, and on what does this difference depend?

How does the form of the surface of the land affect the rainfall?

Show how the amount of the rainfall may

be regulated by the direction of the prevalent winds.

30. Contrast the rainfall on the west and east of the British Islands.

Why are the north western shores of Scotland and the Lake district of England wetter than other parts of the west coast of the country?

31. What is the zone of Constant Precipitation?

Show why the rainfall on the south-western slopes of the Khasi Hills in India should be enormous.

32 Why is a country often rainless which lies behind a range of hills where the rainfall may be considerable?

Show how the Western Ghats afford an example of this.

33. Explain the cause of the dry climate of Peru.

Why are the desert regions from the north of Africa into the heart of Asia so dry?

34. What is the cause of the alternation of rainy and dry seasons?

How do these seasons show themselves in India?

What is the character of the rainfall in north-western Europe?

35. Is there anything in rain besides pure naturally-distilled water?

Describe the action of rain upon the air, and show how this action affects the healthiness of the air, especially in large and crowded towns.

36. When and where is ice formed?

In what forms does ice appear in the air?

At what height in the air would the freezing-point be reached over England in summer?

How much lower than that height does the freezing-point often descend there in winter?

What is the height of the same temperature in the air overlying India?

Upon what conditions does the position of the isotherm of 32° in the air depend?

37. What is the probable nature of many of the fine white cloudlets seen high in the air during summer?

38. Describe a flake of snow.

Is the same kind of structure seen in other forms of ice?

39. Why does snow appear white?

40. When are snow-flakes smallest? when are they largest? why is this?

41. On what parts of the earth's surface does the moisture of the air fall in the form of snow?

Describe how snow is distributed on the Himalaya mountains, and why its height on the two sides of that chain should be different.

42. What is the snow-line?

What is the average height of the snow-line about the equator and towards the poles?

43. Show how snow has a beneficial influence on vegetation.

44, 45. What is sleet, and how is it formed?

46. What is hail?

Describe the appearance of hail-stones.

At what seasons is hail most frequent?

What is supposed to be the origin of hail?

47. Describe the destructive action of a hail-storm.

LESSON XI.—THE MOVEMENTS OF THE AIR.

1. Mention some of the characteristic motions of the air.

2. To what cause are these motions to be assigned?

State the law which governs all movements of the air.

Why should the movements be in the direction laid down in this law?

What is a cyclone?

Describe an anti-cyclone.

How are cyclones and anti-cyclones contrasted as regards the rate of motion of the air and the kind of accompanying weather?

3. Show how the horizontal movement of the wind depends upon the vertical circulation of cyclones and anti-cyclones.

4. What determines the rate of the wind?

5. How may a knowledge of the distribution of atmospheric pressure over the globe be made to furnish information regarding the prevalent winds?

6. Mention the principal causes of difference in atmospheric pressure.

Show how dominant is the influence of temperature.

7. Give some illustrations of this influence.

8. Illustrate the same phenomena from the alternation of land and sea-breezes; and from the day and evening breezes among mountains.

9. Where would you expect that the influence

of the vapour of the air upon atmospheric pressure should be most marked?

Why is the tropical belt of the globe a region of low atmospheric pressure?

What must be the general system of movement of the air round the tropical belt?

How would this system be carried out were there no land in that part of the globe?

What interferes with the regularity of the system?

Where is the system most clearly seen, and why in that region?

At what season does it appear most distinctly?

10. Explain what is meant by the Belt of Equatorial Calms.

11. Explain the cause of the abundant rain in that belt.

How does the air circulate from the equatorial belt?

12. What is the main system of aërial circulation of the globe?

What sets this system in motion?

13. Why do not the air-currents between the equator and poles flow in a due north and south direction?

14. Explain the origin of the Trade-winds, and show why they are north-east winds on the one side and south-east winds on the other side of the equator?

Why did the Trade-winds receive that name?

Between what limits do the Trade-winds blow?

What are the Calms of Cancer and Calms of Capricorn?

15. Explain why the prevalent winds of the West of Europe are from the south-west.

What reason may be given for the tendency of large towns in that part of the world to grow westwards?

16. How are the movements of the upper air-currents sometimes made clearly visible?

17. Show in what way these movements are now and then disclosed during volcanic eruptions.

18. Give further illustrations of the same kind of evidence from the West and East Indies.

19. Explain the origin of "red-fog" and "blood-rain."

21. What influence have the large masses of land upon the regularity of the aërial circulation?

Show how this influence is exhibited by Central Asia.

22. What are Monsoons?

Trace the direction of the monsoons round Asia, and show why they change with the season.

What are the directions of the prevalent winter and summer winds in the Southern States of North America?

Compare Plates II. and III., and show why these winds should blow as they do.

23. What is the origin of local cold winds?

Explain the nature and origin of the Sirocco.

Describe the appearances by which this wind is accompained in Italy, Spain, Africa, Arabia, and the coast of Guinea.

24, 25. What rates of motion have been

observed to be reached by the wind during storms?

Does a storm affect all parts of a country simultaneously? Illustrate the answer by the general course of storms in Europe.

At what rate does a storm usually advance?

26. What is the character of the barometric readings over the region affected by a storm?

What inference must be drawn from these readings as to the nature of the aërial movements during the storm?

What breadth is assigned to the area of low pressure in the centre of a storm?

27. On what condition does the violence of the wind appear to depend?

What might be expected from a fall of the barometer (or a barometric gradient) amounting to two inches in three hundred miles?

Describe the course taken by the air in such a case.

28. Define the two different motions of the air in a storm.

Show why a storm is often renewed after a short calm and blows furiously from another quarter.

29. Show how the circulation of the air in a storm is illustrated by the dust whirlwinds on a roadway.

30. Mention the chief functions of the winds and aërial currents.

31. When do winds raise temperature?

Why is the climate of Britain milder than from its latitude it might be supposed to be?

When do winds lower temperature?

Why are the east winds of Europe dry and cold?

Refer to the charts (Plates II. III. V. and VI.), and point out other districts where the temperature is connected with the direction of the prevalent winds.

32. How does the vapour obtained by the atmosphere from the surface of the sea and land become diffused over the globe?

On what condition does the wetness or dryness of a climate very generally depend?

33. When are winds wet, and when are they dry?

34. What influence does a barrier of high land exert upon a moist warm wind?

What is the amount of the annual rainfall on the Khasi Hills fronting the Bay of Bengal, and to what circumstance is it due?

Trace the subsequent progress of the moisture in the air from the Khasi Hills across the Himalayan chain into the plains of Thibet.

35. What regulates the dry and rainy seasons of countries like India?

36. Why does rain fall at variable and irregular periods in Western Europe?

Why are west winds in that region often rainy, while east winds are dry?

37. Explain the nature and origin of sand-dunes.

38. Give some examples of the effects of drifting-sand along the coasts of Britain.

Describe the sand-dunes of the Bay of Biscay.

39. What are deserts, and how do they illustrate the effects of drifting-sand? (See art. 23.)

CHAPTER III.

THE SEA.

LESSON XII.—THE GREAT SEA-BASINS.

1. How much of the earth's surface is covered with sea, and how much with land?

2. The surface of the sea appears perfectly level; to what amount per mile is it really curved?

What is meant by the horizon?

On what does its distance from us depend?

How much must our eyes be raised above the sea-level to be able to see objects on the sea-level at a distance of three miles?

For what distance is the visible horizon extended when viewed from a height of ten and a half feet above the sea-level?

What is the distance of the horizon seen from a height of ninety-six feet?

4. Briefly enumerate the more striking features presented by the sea.

5. What is probably the average depth of the sea?

What appears to be the limit of depth of the more profound abysses of the sea?

6. If the surface of the earth could be made

smooth and the sea could be spread uniformly over it, what would be the probable depth of such an envelope of water?

7. Why may we not suppose that the great sea-basins have been hollowed out by the sea itself?

8. To what cause must the origin of these basins be assigned?

What is the connection between the origin of these basins and that of the continents?

9. What used to be the prevailing notions regarding the conditions of the bottom of the deep sea?

10. By what means have these erroneous notions been dispelled?

Mention the three chief instruments used in the investigation of the deep sea.

11. What is the sounding-line, and for what purpose is it used?

What is the dredge, and what use is made of it?

How has the thermometer been used in deep-sea research?

12, 13. Describe the geographical features of that ocean which has been most thoroughly explored.

14. Briefly describe the river drainage which is received by the Atlantic ocean.

15. Show from the position of its islands what may be inferred regarding the form of the floor of the Atlantic ocean.

17, 18. State the results of recent soundings regarding the depth of the Atlantic ocean.

19. Mention the greatest depth lately obtained in sounding the Pacific ocean.

20. What appears to be the average depth of the greater part of the North Pacific ocean?

Describe the direction of the ridges which traverse the floor of the Pacific ocean.

21. What are mediterranean seas? Give some examples.

What are inland seas, and how have they arisen?

Describe the Caspian Sea.

Give briefly the history of the changes to which the isolation of the Caspian Sea is believed to be due.

LESSON XIII.—THE SALTNESS OF THE SEA.

1. What connection exists between the sea and the aqueous vapour in the atmosphere?

Why may it be inferred that the sea receives back again by rain and rivers as much moisture as it supplies to the air?

2. What is the distinctive character in the composition of sea-water?

3. What is the specific gravity of sea-water?

What difference has been noted between the specific gravity of the Atlantic and Pacific oceans?

Where has some of the heaviest sea-water been found? what is its specific gravity, and why is this so great?

State the specific gravity observed in the Antarctic ocean.

Mention a striking illustration of the greater lightness of fresh-water as compared with sea-water.

4. Describe what is seen when sea-water is evaporated.

What is the source of the salt taste and the greater weight of sea-water?

5. What is the most abundant substance in sea-water?

How may it be recognised when the water is evaporated?

Why does it appear last in order during evaporation, and disappear first during solution?

6. What average proportion of sea-water consists of saline substances?

Of this proportion, how much consists of common salt?

Mention some of the other salts.

Do the relative proportions of these substances vary much in the different oceans?

7. Whence does the sea get its salt?

How do marine plants and animals help to reveal what substances are dissolved in the water of the sea?

Mention how substances present in extremely minute proportions in sea-water are detected on some of the metallic surfaces of ships.

8. Mention two important substances which are present in extremely minute proportions in sea-water.

What purposes does carbonate of lime serve in the sea?

What is silica, and how is it useful in the sea?

9. How may it be shown that sea-water must contain air?

What proportions of air have been detected in solution in sea-water?

10. What purpose does this dissolved air in the sea-water serve?

How does carbonic acid come into sea-water?

11. What is meant by protoplasm? How is it brought into the sea? And what purpose does it serve there?

12. Give a summary of this Lesson.

Lesson XIV.—The Depths of the Sea.

1. What is the general character of the floor of the sea?

2. Describe one of the pools on a rocky sea-shore.

3. What is the aspect of the sea-bottom below low-water mark?

What is the average breadth of the sea-weed belt which fringes the edge of the land?

Is the sea-floor beyond the sea weed belt uniformly covered with marine life?

4. Within what limits does the largest proportion of the marine population live?

What until recently was the general belief of naturalists regarding the life of the deep-sea?

5. What has been discovered within the last few years on this subject?

State briefly the general distribution of sea-weeds.

6. Mention some of the characteristic features of the sand-banks of the shallow seas round the British Islands.

7. What are mud, sand, and gravel?

Whence are these materials derived which cover so much of the sea-bottom?

What becomes of them in deep water?

8. State generally the new information obtained by the *Challenger* expedition, regarding the deposits of the sea-floor in proximity to land.

What deposits are formed in the deep ocean-basins remote from land?

What is the nature of most of the floor of the Atlantic and Pacific oceans at depths of more than 2,000 fathoms?

What are the nature and origin of the pale deposit found near the icy Antarctic land at depths of nearly 2,000 fathoms?

What other kind of deposit occurs abundantly in the inter-tropical regions of the Pacific ocean?

9. Which is the best known deep-sea formation?

Describe this formation as it occurs on the Atlantic floor.

LESSON XV.—THE TEMPERATURE OF THE SEA.

1. On what influences do changes in the surface temperature of the sea depend?

What is the average temperature of the surface water of the sea on the west side of Britain?

What is the average temperature of the surface water of much of the North Atlantic ocean? and what is it in the equatorial parts of this ocean?

What are the mean surface temperatures of the North and of the South Pacific oceans?

In polar seas what is the usual character of the surface temperature?

In land locked seas like the Red Sea, how high a temperature has been observed?

2. How does the surface temperature of the sea affect climate?

3. Does the surface temperature afford any reliable indication of the general temperature of the mass of water below?

How is the temperature at different depths ascertained?

4. State the general result of recent observations of this kind all over the world.

What has been noted with regard to the temperature of the bottom-water of the open seas communicating freely with the poles?

5. What general fact has been established by the *Challenger* soundings regarding the distribution of ocean-temperature?

Describe the distribution of temperature in the North Atlantic ocean.

State how the temperature is arranged in the South Atlantic ocean.

How is the temperature distributed through the equatorial part of that ocean?

6. Mention some particulars regarding the temperature of the North Pacific ocean.

Describe the general arrangement of temperature in the South Pacific.

7. What conclusion must be drawn from these facts?

Describe the system of circulation which the temperature soundings reveal.

8. Give an account of two different but contiguous sea-climates recently observed at parallel depths in the North Atlantic.

LESSON XVI.—THE ICE OF THE SEA.

1. Describe an iceberg.

What proportion of the mass of an iceberg is immersed in the water?

What happens to an iceberg as it drifts into warmer latitudes?

2. In what part of the North Atlantic are icebergs frequently seen?

How may their approach be detected at sea?

3. Where do icebergs originate?

Describe the ice of North Greenland.

4. What is the proportional influence of winds and of ocean-currents upon the movements of icebergs?

5. What happens when an iceberg gets into shallow water? How is this illustrated on the Labrador coast?

6. What is floe-ice?

Describe how it is formed.

Were the freezing sea-water left undisturbed how thick would it be by the end of an Arctic winter?

What causes prevent the formation of a uniform sheet of ice, and what is the result?

7. What are the water-channels or lanes of the Arctic floes?

8. Describe the appearance of floe-ice where not disrupted.

What happens to the frozen surface of the polar sea in summer?

What influence carries the broken-up floe-ice away from the pole?

How far south have Greenland icebergs been met with?

9. Describe the ice-foot of North Greenland.

What becomes of the ice-foot in summer?

10. What is ground-ice (or anchor-ice)? Where is it formed?

Describe the formation of ground-ice in the Baltic Sea.

Show how ground-ice may change to some extent the character of the bottom of the sea, river, or lake where it is formed.

LESSON XVII.—THE MOVEMENTS OF THE SEA.

1—4. Is the restlessness of the sea entirely fitful and beyond our power to account for and predict?

When the margin of one of the large oceans is attentively watched, what is the first feature to be noticed regarding the cause of the motion of the water?

5. What inference as to movements in the sea may be drawn from foreign plants cast ashore? Show how this inference may be applied to the case of the North Atlantic ocean.

6. Describe the changes in the aspect of the sea-shore due to the tides.

7. Show that the movements of the tides have no connection with those of the air.

8. In what regular intervals do the tides recur?

What has been observed regarding the time of the tides and changes of the moon?

9. What are the chief movements of the sea?

10. To what cause are the waves of the sea due?

What is the appearance of waves seen from some height above the surface of the sea?

Does the water really move as the waves do?

Illustrate this motion of the water from the analogy of a field of wind-swept corn.

11. What is ground-swell?

How does this swell affect the surface of the open sea?

What appearance does it assume in shallower water, and as it reaches the land?

12. To what extent does the motion of waves and ground-swell affect the deeper parts of the sea?

13. What is the relation between the size of the waves and the breadth of water over which the wind blows?

What has been observed to be the extreme height of waves in the North Atlantic during stormy weather?

In the narrow British seas what is the size of the largest waves?

14. Describe the approach, bursting, and recoil of a large wave upon the shore.

15. What has been computed to be the pressure of an undulation of the ground-swell twenty feet high?

Give the average summer and winter force of the Atlantic breakers on the west coast of Britain.

Mention an extreme pressure which has been recorded.

16. What are marine currents?

To what depth do they affect the water of the ocean?

17. What is the connection between the currents of the sea and the general circulation of the air?

18. What is the Equatorial Current, and from what influence does it arise?

What appears to be the limit of its depth in the Atlantic ocean?

19. If no land stretched across the equatorial belt, what would be the direction of this current?

Show briefly the influence of the American barrier to the progress of the current from the Eastern Atlantic.

Trace the course of the Brazil current.

Trace the course of the larger portion of the Equatorial Current which is turned northward by the American Continent.

State the maximum surface temperature and rate of motion of the Gulf Stream as it issues from the Strait of Florida.

Show how the deflection of the warm equatorial water affects the temperature of North-Western Europe.

20. What is the Sargasso Sea, and where does it lie?

21. Describe the course of the Equatorial Current in the Pacific ocean.

22. How does the movement of the equatorial waters affect the rest of the sea?

Mention the cold currents in the Southern and Northern Pacific ocean.

What are the main cold currents in the North Atlantic basin?

How do icebergs show that the cold Arctic current out of Davis Strait must pass under the warm water of the Gulf Stream?

What has recently been ascertained by the *Challenger* soundings to be the temperature and depth of the Gulf Stream between New York and Bermuda, and the position of the Arctic current between New York and Nova Scotia?

23. State the evidence on which it is believed that the oceans are pervaded by a general slow circulation from equator to poles.

24. What influence is exerted by the sun and moon upon the earth?

25. How is the attraction of the sun and moon shown by the ocean?

How does the rotation of the earth affect the protuberant masses of water?

26. Trace the source and the progress of a tidal undulation round the earth.

At what interval do such undulations succeed each other, and what fixes the length of the interval?

27. What is the sun's influence in these phenomena?

When is the tidal undulation at its maximum, and what is the reason?

Give the meaning of the terms *high-water* or *flood*, *low-water* or *ebb*, *spring-tides* and *neap-tides*.

28. How is it that the times of high-water and high spring-tides can be accurately predicted?

How has the length of time been observed

which is taken by the tidal wave to travel from point to point?

On what conditions does the rate of the tidal wave depend?

What rate is reached in the equatorial Atlantic?

How long does the tide-wave take to come from the south of Africa to the south-west of Europe?

Describe the progress of the wave when it reaches the south-west of Britain.

29. What is the nature of the motion of the water in the tidal-wave?

How does the character of the motion change in shallow water, and why?

30. What is the amount of rise of the tide in the middle of the Pacific ocean, and in the Atlantic at St. Helena?

Under what conditions does the tidal undulation become a rapidly rushing wave or current?

To what height do the tides rise in the Bay of Fundy?

Describe the aspect of the flowing tide in the estuary of the Severn.

Mention some of the rivers of Western Europe at the mouths of which the advancing tidal undulation gives rise to what is called a *bore*.

Describe the bore of the Seine.

31. What is a *race* in the sea? Explain its origin.

Give an account of the passage of the tidal current through the Pentland Firth in the north of Scotland.

32. What is the origin of whirlpools? Mention some examples.

33. What is a beach?

Explain the meaning of the terms *high-water mark* and *low-water mark*, and show why the interval between these limits varies much in different places.

LESSON XVIII.—THE OFFICES OF THE SEA.

2. What is the system of circulation of moisture between the earth's surface and the atmosphere, and what part does the sea take in it?

3. What is the probable condition of the air overlying the sea with respect to its proportion of moisture?

Why are maritime districts wetter than inland places?

What has been stated to be the amount of evaporation from the surface of the sea near the coast of India?

What is believed to be the annual loss by evaporation from the surface of the Red Sea, and from the trade-wind region of the oceans?

4. How is the copious amount of moisture which is evaporated from the sea in tropical regions disposed of?

Why can little of this vapour pass over to the temperate regions on either side of the equator?

5. What is the chief source of the rains of Europe?

From what quarter come the rains of Southern Asia and Eastern Africa?

How are the rains brought to India and China?

What is the source whence the rivers of Western Africa are supplied with moisture?

From what quarter are the rains brought which water the western slopes of the Rocky Mountains?

How is moisture carried across South America.

6. State in general terms the way in which marine currents affect the distribution of temperature.

7. What arrangement of the currents in the North Atlantic favours the climate of the north-west of Europe?

Do the average winter temperatures of the sea and of the land on the west of Britain differ?

How is it that a warm marine current or drift influences the temperature of the land?

Show how this influence is increased as the warm water moves across the Atlantic.

8. Compare the temperature of corresponding latitudes in the north of Norway and on the east coast of Greenland.

Compare the temperature of some places on the west coast of Britain with the same latitudes on the east coast of North America.

9. On what conditions do these contrasted temperatures depend?

What has been observed as to the sea-temperature off the coast of Nova Scotia even as far south as latitudes corresponding to those of the South of France?

10. What difference as to distribution of

temperature is to be noted between the regions of the globe which are mostly sea and those where large masses of land exist?

What are continental and insular climates, and on what conditions do they depend?

11. State the general action of sea-waves upon the margin of the land.

How is the destructive influence of waves aided by the atmosphere?

12. What use is made by the waves of the loosened fragments of rock?

To what are these loosened fragments finally reduced?

13. Large blocks of stone are sometimes started from their places in sea-walls during storms; masses of rock are detached from cliffs, or tunnels and caves are excavated in them by the waves. Explain how these effects are produced.

14. At what rate does the sea advance upon the land on some parts of the east coast of England?

What historical evidence exists of the amount of land thus cut away?

15. Is the sea everywhere eating into the land?

Where is it chiefly doing so?

Where is its destructive influence least marked?

How does the sea in other places add to the land?

Give some examples of this action.

16. What becomes of the material worn by the waves from the land or swept into the sea by rivers?

17. What traces of old sea-bottoms may be met with on the land?

What inference may be drawn from these as to the future of the deposits which are now forming on the sea-floor round the land?

18. How is this inference further borne out by comparing such rocks as the chalk of England and France with the ooze formed of minute forms of animal life as described in Lesson XIV.?

19. Within what limits is most of the destructive work of the sea effected?

Are the deeper parts of the sea stirred by waves?

Consider, as a whole, what must be the influence of the sea upon the surface of the solid earth.

CHAPTER IV.

THE LAND.

LESSON XIX.—CONTINENTS AND ISLANDS.

1. WITHIN what limits is actual observation of the constitution of the interior of the solid earth necessarily restricted?

2—6. Give a summary of these five paragraphs, so as to show briefly the nature of the subject now to be entered on.

7. What is computed to be the area of dry land on the globe?

How is it distributed from the Arctic Circle southwards?

How may the continents be conveniently grouped?

8. What is the prevalent direction of the continental masses?

Trace this direction in the case of Asia, and of Europe and Africa.

What has determined the shape of the Atlantic basin?

9. What superficial indications exist as to the general shape of the submarine parts of the earth's surface?

10. Describe briefly the distribution of islands in the Pacific ocean.

11. How much do the highest summits of the Pacific islands rise above the sea-level?

How lofty are these summits above the general level of the bottom of the Pacific ocean?

12. Do the Pacific islands point to continuous submarine ridges?

Where was the deepest ocean-sounding obtained, and what was its depth?

13. Trace the direction of the principal groups of islands in the Atlantic basin.

14. What evidence is furnished by the Indian ocean as to the direction of submarine ridges upon the earth's surface?

15. By what two limits is the form of the land defined?

16. What relation do the actual forms of a coast line usually bear to the delineation shown upon a map?

Name some of the terms expressing varieties of coast-line, and point to examples of them upon a map.

17. What relation has been observed between the slope of the land and the depth of the adjoining sea?

18. How is the form of a coast-line affected by the nature of the rocks?

19. In what respect are the coast-lines of the northern and southern continents contrasted?

Give the proportion of coast-line to superficial area in each of the three pairs of continents.

20. Which of the continental pairs shows the most marked contrast in this respect?

Trace the effects of this contrast upon civilization in the two continents.

21. What is meant by the relief of the land (Art. 15), and how far can it usually be understood from maps?

22. What is the extreme height to which the surface of the land rises above the sea?

What proportion does this distance bear to the polar diameter of the earth?

How large would the loftiest portion of the Himalayan chain appear if represented on a true scale upon a globe ten feet in diameter?

23. State what has been computed to be the average height of the land above the sea, exclusive of Africa and Australia.

Give the average height assigned to Europe, Asia, and Africa respectively.

To what extent would the general level of Europe be raised if the mass of the Alps could be ground down and spread over the continent?

24. Have the irregularities on the surface of the land arisen at random?

25. What is the axis of a continent? Does it coincide always with the crest of the mountains or the centre of the continent?

Give examples from America and Europe.

26. State the relation borne by the slopes on two sides of a continent to the position of the axis.

Give illustrations of this relation from South America, Scandinavia, and Britain.

27. How are the axes of the continents placed with reference to the oceans?

Cite examples from the American and Asiatic continents.

How much on an average does the gentle

slope of a continent exceed in length the steep slope?

28. There is sometimes a further arrangement of the surface of a continental mass with reference to the smaller ocean: what is that?

Show how this arrangement is displayed in North America.

29. What is a common characteristic of the central regions of a continent?

Show how this feature is illustrated by America and Europe.

30. How do these central plains usually slope?

How do lakes arise on the surface of the land?

Have all lakes outlets?

Mention some characteristic examples of drainage into lakes or inland seas without outlets, in Asia, America, and Europe.

Lesson XX.—The Relief of the Land—Mountains, Plains, and Valleys.

1. Are the heights and hollows of the land disposed at random?

2. What is the leading feature in the surface of a continent?

Show the importance of mountain-chains in the structure, drainage, and climate of a continent?

3. How is the word "mountain" used?

What is commonly the origin of large solitary conical mountains?

What is the usual relation of a mountain to its surrounding ground?

Define the terms *mountain-range* and *mountain-chain* or *mountain-system.*

4—7. Give a summary of these paragraphs, showing the more striking features of the chain of the Alps.

8. In what manner does vegetation serve to mark successive heights among the Alps? (See fig. 78).

How is this shown on the Himalayan chain?

9. How are valleys arranged in a mountain-chain?

Illustrate this arrangement from the Alps.

10. Show from the structure of America the connection between mountain-chains and the axis of a continent.

What is the trend of the chief mountain-chain of the Old World?

12. Where do plains occur?

Describe the distribution and character of the chief plains of North America.

What are "prairies" or "savannahs?"

13. Trace the general boundaries of the great European plain.

Where is this plain prolonged into Asia?

What are the "black lands" of Russia?

What are the "steppes"?

What and where are the "tundras"?

14. What is the North African desert?

15. Explain the mode of reasoning by which it can be shown that many sandy plains have once formed the bottom of the sea.

16. What are "table-lands" or "plateaux"?

17. Give examples of table-lands enclosed by mountains.

18. What is the general physical structure of Africa, and of the Spanish peninsula?

19. What curious alteration has taken place in the ancient table-lands of Scandinavia and the Scottish Highlands?

LESSON XXI.—THE COMPOSITION OF THE EARTH.

2. What is the usual character of the superficial covering of the earth's surface?

3. What underlies the vegetable layer?

Mention some of its varieties.

With what common character are these differences of aspect associated?

How do plant-roots and earth-worms influence the soil?

4. Besides the inorganic materials, what further important ingredient in soil is to be noticed?

Whence is this ingredient derived, and of what use is it in the soil?

5. Mention the average thickness of soil.

What is the next layer below the soil called, and what is its origin?

In what relation does the soil stand to the subsoil?

Show how it is that subsoil is gradually converted into soil?

6, 7. What underlies the subsoil?

Why does the character of the soil vary in different districts?

8. What is the origin of many of the rocks of the land? Give some examples.

9. Where may rocks formed of water-worn materials be seen?

Why are they called stratified or bedded?

10. What is the origin of coal?

11. How have limestone and chalk been formed?

12. How are those rocks distributed over the land?

13. What appear to have been the modes in which most of the rocks forming the solid land have been formed?

What inferences may be drawn from them as to the history of the land?

14. What are the characters of another great series of rocks which cannot be classed with the stratified series?

Mention some examples.

How are these rocks distributed over the land?

15. What is the origin of these crystalline rocks?

What inference may be drawn from them as to the structure of the earth's interior?

16. Mention the general order in which the rocks of the land occur from the soil downwards.

Have any rocks been found older than the crystalline series?

17. What is the specific gravity of most rocks at the earth's surface?

What has been determined to be the density of the earth?

18. How is the density of bodies affected in proportion as they approach the centre of the earth?

What would be the density of air at a depth of 34 miles, and of water at 362 miles?

If this progressive increase took place unchecked by any other influence, the specific gravity of the earth should be much higher than it has been ascertained to be. What appears to be the reason that the specific gravity is no higher than 5·5?

19. What proportion do the deepest mines bear to the semi-diameter of the earth?

What sources of information are available for showing that the interior of the earth has a high temperature?

20. What has been observed regarding the air of deep mines?

Give some examples of the rate of increase of temperature downwards.

What general deduction as to this rate has been made from observations all over the world?

21. If this rate were to continue, what would be the temperature of water at depths of 12,000 feet, and 24 miles?

22. Where do warm springs occur?

What is the temperature of the hottest springs in Iceland, and how does the water behave as it approaches the surface?

23. Give some illustrations of the occurrence of warm springs far removed from active volcanoes.

Give an example of warm water still issuing from the ground in a region where volcanic action once abundant has never shown itself within human history.

Mention the way in which hot springs occur in mountain-chains.

24. What are Geysers?

Describe the Iceland geysers.

25. Where do geysers occur in North America?

What remains to mark the position of extinct geysers?

26. In New Zealand how have some of the hot springs changed the forms of the sides of their valley?

27. What are volcanoes?

What inference may be drawn from them as to the earth's internal temperature?

28. From all this evidence it is concluded that the inside of the earth must be intensely hot. State two opinions which have been formed as to the condition of this heated mass.

29. Why does not the progressive increase of temperature downwards in the earth prove the centre to be fluid?

What appears to be the most probable condition of the earth's interior?

30. What kind of evidence tends to indicate the existence of a metallic nucleus within the earth?

31. Give a brief summary of what has been stated in these Lessons regarding the constitution of the earth?

LESSON XXII.—VOLCANOES.

1. Why are volcanoes called by that name?

How is the word volcano applied?

What are the signs of an active volcano?

What is the meaning of the term "volcanic action"?

How are the terms "dormant" and "extinct" used in reference to volcanoes?

2. Mention some of the extremes of size among volcanoes.

3. What is a crater?

What is the nature of the materials ejected from a crater?

What is lava?

How does a volcano increase in width and height?

4. How are smaller cones formed upon the flanks of a volcano?

5. What phenomena mark the early stages of a volcanic eruption?

What is the origin of the abundant rain which so often accompanies an eruption?

Give an illustration of the abundance of the fine volcanic dust sometimes blown out from a crater.

What sometimes becomes of the fine dust which ascends to great heights in the atmosphere?

6. Mention some further solid materials ejected by an active volcano.

Give examples of the force with which these are occasionally expelled.

7. What is the origin of the abundant dust and stones in a volcanic eruption?

What part does superheated water play in the phenomena of a volcano?

What is the origin of a volcanic explosion?

8. Account for the disappearance of the upper part of a volcanic cone during an eruption.

Show how Vesuvius illustrates your answer.

9. What causes the lava to rise in the volcanic funnel?

Why does the lava sometimes flow out from the lip of the crater, but more usually from the outer slopes of the cone?

10. Describe the course of a lava-stream from its point of escape.

Give examples of different rates at which lava has been observed to flow.

11. Describe the appearance of a lava-stream where it creeps slowly down a slope.

12. Give some examples of the distances to which lava-streams have flowed.

How did the lava-floods of Skaptar Jokul in 1783-5 alter the surface of that part of Iceland, and what has been computed to be the volume of the lava?

13. What is the character of the surface of a lava-stream, and what influence has it upon the rate of cooling of the mass below?

14. What is the usual character of a volcanic eruption after lava has begun to issue freely?

After all explosions and ejections of dust, stones, and lava have ceased, how does volcanic action manifest itself?

When and how does carbonic acid gas escape in a volcanic district?

15. What is the estimated number of active volcanoes on the globe?

How are they generally distributed?

Trace the course of the volcanoes round and within the Pacific basin.

16. By what route are active volcanic vents

prolonged from the Pacific basin across Asia and Europe to the Atlantic?

17. Mention the position of some more isolated volcanoes.

18. Are the present abundant active volcanoes of the globe the only evidence to show how widely volcanic action has been manifested over the earth's surface?

Give an illustration of extinct volcanoes.

19—21. From what was stated in the last Lesson regarding the probable condition of the earth's interior, how may we explain the linear arrangement of volcanoes and their coincidence with marked ridges upon the surface of the planet?

What is it which appears to be the means of enabling the intensely-heated materials of the interior to find their way to the surface?

Lesson XXIII.—Movements of the Land.

1. Mention some further effects of the internal condition of the earth upon its surface?

2. What are earthquakes? Mention some of the various degrees in which they are manifested.

3. Describe the more marked effects of a severe earthquake upon life and property.

4. Are all the portions of a region which is affected by an earthquake shaken at the same moment and in the same degree?

How are the approach and passing of an earthquake marked?

5. What is the nature of the earthquake movement?

6. What is the occasional effect of the undulation upon steep banks and cliffs?

7. What has been observed in regard to the rending open of the ground?

8. How does an earthquake sometimes affect the level of a region?

How was this influence shown in the case of the Chili earthquake of the year 1835.

Describe the effect of the earthquakes in the years 1811—1813 upon parts of the valley of the Mississippi.

9. Describe the effect of an earthquake shock under the sea.

10. What difference in rate of motion is observed between the sea-wave and the earthquake shock?

Mention some of the destruction caused by the sea-wave in the Peruvian earthquake of August, 1868.

11. Is the true cause of earthquakes properly understood?

State some of the explanations which may be given.

At what part of a convulsed district is the shock most severely felt?

12. How may the probable depth of the source of origin of earthquakes be estimated?

What conclusion has been drawn by Mr. Mallet regarding the probable depth from which earthquakes proceed?

13. State the general distribution of earthquake regions over the globe.

14. Give the extent of country affected by the great Lisbon earthquake and the Peruvian earthquake of August, 1868.

15, 16. In addition to the sudden shocks of earthquake the ground is affected by more gentle movements. Show various kinds of evidence whereby these movements may be detected?

17. What is the nature and rate of the change of level observed in the south of Sweden?

What proofs of the elevation of the land have been observed in Great Britain, Spitzbergen, and the north of Russia and Siberia?

What inference may be drawn from the tundras and steppes as to changes in the level of the region between the Caspian and Arctic seas?

What evidence is furnished by the Sahara as to similar changes?

18. By what kind of evidence may a subsidence of the land be shown?

19. What are Coral-reefs?

What is the structure of a Fringing reef? Where do reefs of this kind occur?

20. What are Barrier reefs, and where may they be found?

21. What is an Atoll?

How does the coral ring of an atoll gradually become converted into dry land and receive a coating of vegetation?

22. Why is it certain that the coral-reefs have not grown up from the bottom of a profound ocean?

What is the limit of depth at which it is believed that coral will begin to form?

What deduction has been drawn from the present great thickness of the coral-rock and the profound depth of the water outside of the reefs?

23. Enumerate the successive stages in the formation of a coral-island or atoll.

How may the existence of steep submarine cliffs of coral be sometimes explained without necessarily requiring subsidence of the sea-bottom?

24. Mention some of the principal regions of atolls.

What is specially to be noticed regarding some of those in the Indian ocean?

LESSON XXIV.—THE WATERS OF THE LAND.

Springs and Underground Rivers.

1—3. State briefly the general characters of the circulation of water over the globe.

4. In what forms does the moisture of the air chiefly descend to the earth?

5. What becomes of the rain when it reaches the surface of the land?

Why may we be sure that the rain which sinks under ground is not permanently withdrawn from the surface?

How is this underground water restored to the surface?

6. Show that springs are dependent on rainfall.

Why are deep-seated springs less variable than those which are of shallower origin?

7. Through what various channels does rain-water descend under ground?

Besides rain, from what further sources does subterranean water come?

8. By what kind of evidence can it be shown that the water of brooks and lakes sometimes finds its way into underground passages?

9. How does the descent of surface water affect the rocks underneath?

Mention some familiar proofs of the abundance of underground water.

What is the principle on which ordinary wells are constructed?

Show by some examples that underground water is not always merely derived from the rainfall of the district which it underlies.

11. What conditions largely determine the depth to which water will descend?

Is it necessary to suppose that the underground water generally sinks to a great depth?

What happens when some of the water descends to the intensely hot sources of lava?

By what process may some part of the subterranean water be permanently removed from circulation?

12. In what manner does the rain which sinks beneath the soil reappear at the surface?

13. What causes the water which sinks down into the earth to gush forth again in springs?

14. Explain the mechanism of surface springs.

15. What is meant by the water-level in regard to wells and borings for water?

16. Explain the mechanism of deep-seated springs.

By what natural openings do deep-seated springs issue at the surface?

Show how a line of springs may serve to

indicate the line of a dislocation in the rocks underneath.

17. Why may we believe that the course of the water underground is exceedingly circuitous?

18. Why are some wells called Artesian?

What is the principle on which these wells are made?

Give examples of the force with which the water sometimes issues from Artesian wells.

Explain the construction of these wells at London.

19, 20. Why do not springs furnish an adequate measure of the amount of underground water in circulation?

How does that portion of the water show itself, which, though issuing at the surface, does not take the form of proper springs?

What has been observed regarding the underground drainage beneath the Mediterranean Sea?

21. Point out the important part taken by springs in preserving the general verdure of the surface of the land.

22. What difference is to be noted between the purity of rain and of the water of springs?

How may mineral substances chemically dissolved in spring-water be made visible?

Does this mineral impregnation always give a marked taste to the water?

Mention some figures showing the extremely variable proportions in which mineral substances are dissolved in the water of different springs?

24. What usually happens when a glass of

fresh spring-water is allowed to stand for a few hours?

How may this result be accounted for?

Why has the water when boiled an unpleasant, insipid taste?

25. What has been found to be the nature of the gas dissolved in spring-water?

In what variable proportions has the gas been found to occur?

26. What is the nature of the film or powder left behind when a quantity of water is evaporated to dryness?

What is *hard* water? and where may it always be expected to occur?

What is *soft* water, and what is the softest water available for domestic use?

How does hard water affect kettles and boilers in which it is used?

27. What are Mineral Springs?

What is the mineral chiefly present in calcareous springs, and how does it show its presence as the water trickles away from the springs?

What are ferruginous or chalybeate springs?

How does iron affect the taste of the water, and what visible form does it take as the water flows on at the surface?

What are salt and brine-springs?

When is a brine-spring said to be saturated?

What are medicinal springs?

Mention the chief characters of some celebrated medicinal springs in England and on the continent of Europe.

28. What extremes of temperature may be observed in the water of springs?

On what relation does the temperature of springs depend?

How may the temperature of springs be employed as an indication of the probable depth of their sources?

29. Warm or thermal springs usually contain much more dissolved mineral matter than cold springs. Why is this?

Give the temperatures of some warm springs in Europe.

Mention one of the most characteristic ingredients of the water of boiling springs, and state how it appears when the water cools?

30. What is the range in the proportion of mineral substances contained in common spring-water?

What proportion of these substances may be contained in "hard" water?

Mention some high proportions in European mineral waters and compare these with the proportion of salts in the water of the Atlantic Ocean and Dead Sea.

31. Whence is the mineral matter derived?

Show by some examples how enormous must be the amount of mineral matter abstracted from below and carried to the surface by springs.

32. From what various sources may underground water receive carbonic acid.

33. Describe the white incrustation often found on the under sides of the arches of vaults and bridges.

34. Explain the formation of this incrustation.

35. What becomes of the lime still retained in the water-drops which fall to the ground?

How are the terms *Stalactite* and *Stalagmite* used?

36. May we expect that if rain-water, passing through a few feet of masonry, can effect so much, underground water must decompose the rocks and in course of time produce great subterranean changes?

38. Show how the mineral substances removed by springs are connected with the growth of animals in rivers, lakes, and the sea.

How would the absence of these mineral substances in water affect man?

39. What is the result of the continued abstraction of mineral matter from subterranean rocks?

How does a limestone district illustrate this kind of action?

40. Describe the honeycombed structure of the Karst in Carniola.

41. State some of the dimensions of the Mammoth Cave of Kentucky.

Give the dimensions and position of the grotto of Antiparos.

42. Why is the surface of a limestone country often full of holes?

What is the origin of the lakes without surface outlets in limestone districts?

Describe the Zirknitz See in Carniola.

43. Besides the changes of the surface due to the chemical solution and removal of underground rocks by percolation, the subterranean circulation of water affects the surface in another way. What are landslips, and under what conditions do they occur?

What is the undercliff of the Isle of Wight?

What is the cause of the remarkable landslips on the coast of Antrim?

44. Where are landslips of frequent occurrence?

How is the surface of the ground altered from this cause in some parts of India?

What often takes place when a landslip is thrown across the course of a stream?

45. Give an illustration of the great destruction to life and property caused by landslips.

LESSON XXV.—THE WATERS OF THE LAND.

Running Water.—Brooks and Rivers.

1. What becomes of that portion of the rain which does not sink underground?

2. What are water-courses?

3. What is the general arrangement of the drainage lines on a continent?

4. Where must the sources of large rivers be sought?

What is the character of a river which issues from the melting ice of a glacier?

What is the character of the first or torrent-part of the course of a river which takes its rise from a spring?

5. Describe the second or valley-part of the river's course.

6. What is the character of the last or delta-part of the river's course?

7. Do rivers run in straight lines like canals across a country?

Illustrate this general character of river-

courses by what takes place upon a sloping road during heavy rain.

Why do rivers wind from side to side?

8. What becomes of a loop in a river-course when it is cut off from the main stream?

9. Why is it inconvenient to speak of the east and west or north and south banks of a river?

What terms are substituted for these?

10. What relation does a river bear to the drainage of the district or country through which it flows?

What is meant by a drainage-basin?

What is the extent of the drainage-basins of the Mississippi, of the Ganges, and of the Rhine?

State the area inclosed in the catchment basins of the Thames, Shannon, and Tay.

11. What is meant by water shed?

Trace the water shed of the Mississippi.

12. Does a water-shed necessarily correspond with a line of ridge or with the highest ground?

Describe the line forming the water shed of the European continent from Gibraltar to the Ural mountains.

13. Does a water-shed usually run along the centre of a country?

How does the position of the water-shed indicate the relative inclination of slope of the two sides of a country?

Show how this is illustrated in the case of South America.

Trace on maps the water-sheds of Scandinavia, Great Britain, and Spain.

14. Why are large rivers found on the long

slope and not on the short slope of a country?

Trace on a map the river-systems of South America by way of illustration.

15. What is usually meant by the source of a river?

How has the main branch of a river usually been determined?

16. From what various sources do large rivers rise?

What is the source of a large proportion of rivers?

In limestone countries what is sometimes the source of large streams?

To what is the usual rise of the Nile due?

Give examples of rivers which take their rise among mountain snows.

How are lakes connected with rivers as sources of supply?

17. What proportion of the rainfall and snowfall is estimated to be carried to sea by rivers?

What becomes of the rest of the moisture?

Does a river pour into the sea all the water which it receives in its course?

18. Where are rivers liable to be flooded at irregular and uncertain intervals?

Where is there a regular rise and fall in rivers?

Egypt, an almost rainless country, is every year overflowed by the waters of the Nile. Explain the cause of this.

19. Describe the cause of the annual flooding of the Mahanadi and other rivers in Central India.

20. What are "wadys"?

What inference may be drawn from the "wadys" as to a change in the climate of the west of Asia?

21. When a river rises from melting snow and ice, during what part of the year is its volume largest?

Describe the connection between warm weather and floods in the rivers of the Alps.

22. What determines the rate of flow of a river?

What is the average slope of the larger rivers?

State the mean fall of the Missouri and the Volga.

What is the limit of slope in rivers for easy navigation?

Give examples of the angle of slope in the mountain-track of rivers.

23. At what rate does the water of a moderately flowing river move?

What is the maximum velocity of a torrent?

State the average rate of flow in the larger rivers in Britain.

24. What difference is observable in the velocity of different parts of the water of a river-course, and to what cause is it due?

What is the effect produced upon the velocity of a river by the addition of tributary streams?

Explain this effect.

Why is the breadth of a river sometimes not increased even by the addition of large tributaries?

Illustrate this phenomenon by the case of the Mississippi.

25. What is the estimated annual water-discharge of the Mississippi?

State the water-discharge of the Danube.

How much water does the Tay discharge annually into the sea?

LESSON XXVI.—THE WATERS OF THE LAND.

Lakes and Inland Seas.

1. What are lakes, and inland seas?

2. What general remark may be made as to the distribution of lakes over the surface of the land?

3. Where do lakes occur most abundantly in the northern hemisphere?

How do lakes affect the scenery in Finland, the north-west of Scotland, and in British North America?

4. State the explanation given by many geologists regarding the abundance of lakes in the northern hemisphere.

5. What relation may often be observed between the occurrence of lakes and of mountains, particularly where the mountains are either situated in cool latitudes or lofty enough to nourish a constant store of snow and ice?

Give examples of this relation.

How may it be accounted for?

Why do lakes occur in most volcanic districts?

6. Give examples of the occurrence of lakes on table-lands in Africa and Asia.

7. Many of these lakes on table lands have

no outlets: what is to be remarked regarding the character of their water?

Explain this peculiarity.

What is the condition of the soil surrounding these lakes, and what is left when the water disappears from the basins?

8. Explain how a fresh-water lake may occur in a region where the other lakes are salt, and give an example.

9. Explain the meaning of the passage in the Sermon on the Mount—"If the salt have lost his savour, wherewith shall it be salted? it is thenceforth good for nothing, but to be cast out, and to be trodden under foot of men."

10. What are the lagoons of a sea-coast?

Describe their occurrence in Europe.

Give examples from Asia and from the United States.

11. What is the general aspect of lagoons?

When are they salt, and when are they brackish?

12. From what source do most lakes receive their supply of water?

How is the character of a river affected which flows along a valley containing a chain of lakes?

13. Mention another source of water supply to lakes.

Show how such subterranean supplies may sometimes of themselves form a large lake.

Give the case of the Sebka-el-Faroun as illustrating the dependence of temporary lakes upon the seasons.

14. Give the area, average depth and height above the sea of Lake Superior.

Where are the large African lakes situated?

State the height above the sea and the area of Lake Baikal in Central Asia.

How does the wind affect these vast sheets of water?

15. What general relation may be observed between the slope of the ground around a lake and the probable depth of the water?

Give examples of the depth of Alpine lakes.

What is remarkable about the depth of Loch Ness in Scotland?

16. How might traces of the former presence of the sea be possibly preserved in some of the deeper fresh-water lakes?

17. What has been observed regarding the distribution of temperature in Loch Lomond in Scotland?

Why should the bottom water of such lakes be permanently cold?

What has been noted as to the difference between the temperature of the surface and of the bottom of the Lake of Geneva in autumn, and between the mean annual temperature of the surface water at the outlet of the lake and that of the air overlying it?

What is the general result of observations on the temperature of deep lakes in Switzerland and Italy?

What is the influence of lakes upon the temperature of the air surrounding them?

18. Explain how lakes regulate the flow of the rivers issuing from them.

What influence do lakes exert upon the clearness of the water flowing into them, and how are they affected by this action?

Give an example of this process.

20. Where may salt or brackish-water lakes be expected to occur?

Is it necessary always to suppose a former connection between a salt lake and the waters of the sea?

How might a fresh-water lake become salt?

What are the dimensions and height above the sea of the Great Salt Lake of Utah?

21. What are Inland Seas?

How may they have arisen?

Where does the most remarkable series of such seas occur?

Mention the area and depth of the Caspian Sea, and its position with reference to sea-level.

What area of country drains into the Caspian basin?

What is the average proportion of salt in the water of the Caspian Sea?

Describe where and under what conditions salt is at present being deposited in the Caspian Sea?

22. State the dimensions of the Sea of Aral and its height with reference to sea-level.

What supplies of fresh water does it receive?

What is the character of its own water?

How is its surplus water disposed of? Do evaporation and inflow exactly balance each other there?

23. What evidence may be adduced of the former presence of the sea between the basin of the Caspian and the Arctic Ocean?

24. What is the position of the Dead Sea with reference to sea-level?

What is the proportion of salt in its water?

LESSON XXVII.—THE WATERS OF THE LAND.

The Work of Running Water.

1, 2. Give a brief description of the system of water-circulation over the land.

3. What chemical effect has rain upon rocks on the surface of the land?

Which kind of rock suffers most from this action?

How does the rain acquire this solvent power?

What is the mechanical effect of falling rain upon rock-surfaces?

4. In what form may the simplest illustration of the mechanical action of rain be observed?

Show how masses of coarse stiff stony clay may be cut out into pillars by the action of rain.

What becomes of the materials so removed?

5. What three phases in the work of running-water may be traced in the operations of the rain-drops?

6. What is meant by erosion?

How is erosion effected chemically?

7. How is erosion effected mechanically?

To what process do stones owe their frequently smooth or water-worn appearance?

What inference would you draw from the occurrence of sharp edged fragments of stone in a river channel?

Why may a river be compared to a vast mill?

8. Why is the water-worn character shared by the solid rocks of the water-courses as well as by the loose stones?

Within what limits is this smoothed appearance produced?

9. How are winding ravines formed by running water?

10. What are *pot-holes*, and how are they formed?

What inference may be drawn from the traces of old pot-holes seen high above the present level of the streams?

11. How do waterfalls act in the erosion of ravines?

What circumstances are required to preserve waterfalls as these gradually eat their way up stream?

How may a waterfall be converted into rapids?

12. State the dimensions of the Falls of Niagara.

What is the length of the ravine which has been excavated during the recession of these Falls?

What estimate has been made of the rate of recession, and according to that estimate how long a time has been required for the formation of the ravine?

13. How do floods increase the erosive power of streams?

14. Under what circumstances does the sediment suspended in streams fall to the bottom?

In what forms is mineral matter transported by streams?

How may the amount of invisible mineral

matter be estimated which is carried from the land by a river?

Give Bischoff's calculation regarding the amount of lime invisibly dissolved in the water of the Rhine.

Mention the quantity of dissolved salts estimated to be carried annually by the Rhone past Avignon.

15. Why are streams muddy?

On what does the amount of transported sediment depend?

What various causes determine the carrying power of a river?

Show how the amount of sediment depends upon the character of the rainfall?

16. What kind of sediment is moved by a stream flowing with a current of about half a mile in the hour?

What rate of motion is required to move fine gravel?

What kind of detritus may be swept along when the velocity of the current rises to three feet in a second?

How large are the fragments of rock which may be moved by a flood?

17. Besides the fine mud which discolours a river, what additional kinds of detritus may be moved along the bottom, and how are these sometimes audible.

18. State the proportion of sediment by weight in the water of the Ganges during flood, and on the average for the whole year.

What proportion by weight of sediment occurs in the Irrawaddy during floods and during the dry season?

What average proportion occurs in the water of the Mississippi?

State the proportion in the water of the river Danube.

19. How much earth, sand, and gravel is the Mississippi estimated to push annually along its bottom into the Gulf of Mexico?

20. How may the total quantity of sediment be estimated which a river removes from the land within any given time?

State the estimated discharge of sediment by the Rhone into the Mediterranean.

What is calculated to be the annual amount of silt carried by the Danube into the Black Sea?

State the estimated amount of solid matter carried in suspension by the Mississippi into the Gulf of Mexico in one year?

If this amount were collected, together with the quantity pushed along the bottom, how large a mass would it form?

Illustrate the vast carrying power of the Mississippi by comparing it with the work of a fleet of merchant vessels.

21. Give examples of rivers which transport a still arger relative amount of sediment.

22. What is the relation between the amount of mineral matter conveyed to sea by a river, and the amount of loss sustained by the land which that river drains?

How may the extent to which a river-basin is lowered be estimated?

Dividing the drainage area of the Mississippi by the amount of sediment annually carried by that river into the sea, what do we obtain as the

amount of waste of the general surface of the area?

At this rate of denudation, how long a time would elapse before North America would be reduced to the sea-level?

What important use have such calculations?

23. State briefly the nature of the work of transport carried on by all rivers.

24. What happens to the sediment suspended in running water when the velocity of the water is checked?

When does this take place?

25. Beginning at the early mountainous part of a river's course, where do we encounter the first marked deposit of sediment?

How does this deposit among the mountains interfere with roadways?

26. As a rule what is the kind of sediment arrested at the foot of the mountain slopes?

What becomes then of the finer sediment?

When a stream winds to and fro along a flat valley-bottom or plain, where may sediment be looked for?

27. What happens to much of the mud of a flooded stream which overflows flat meadows?

What part is taken in this process by the grass and brushwood of the level tracts?

What appearance does the inundated ground present on the retirement of the water?

28. If the plain is thus continually heightened by the stream, it must in the end become too high to be reached even by the highest floods. How is this result effected?

Explain the nature and origin of river-terraces.

How may it be shown that very considerable changes in the general scenery of some river-valleys in Europe have taken place since man first appeared in that part of the world?

29. What happens to the sediment of a river which has to traverse one or more lakes?

Where does this chiefly take place?

How is the process illustrated in the Lake of Geneva?

30. If this process continues without interruption, what must happen to the lakes where it takes place?

Give examples of different stages of the change.

31. When a river enters low-lying land what change may be observed in its rate of flow, and consequently in its transporting power?

How is a wide level river-plain formed?

What is the nature of the materials to the levelling out of which the plain owes its origin?

32. When a plain is long and either level or sloping towards the sea with an exceedingly slight inclination, what may be observed in the disposition of the river-sediment?

When in this way the river has come to heighten the bottom and sides of its channel, what danger does it carry to the surrounding country? Give examples.

33. What is the nature of the bottom of the valley of Lower Egypt?

Describe the annual changes of the River Nile.

To what is the rise of this river due?

After the inundation has ceased, what is

observed regarding the surface of the ground from which the water has retired?

What estimate has been formed as to the thickness of such annual deposit and the age of the soil in Lower Egypt?

Whence is the Egyptian mud brought?

How are the three great functions of a river —erosion, transport, and deposit—illustrated by the Nile?

34. Show how similar changes have been wrought in the great plains of India, and in the valley of the Persian Gulf.

Give some further examples from America?

35. What is a *Bar* at the mouth of a river, and how is it formed?

Why does it shift its position from time to time?

36. What is a *Delta?*

What striking difference may be noted between the flow of a river in the previous parts of its course and in the delta?

What effect has the multitudinous branching of the river upon the deposit of sediment in the delta?

Where is the seaward increase of the delta most apparent?

37. At what rate does the delta of the Mississippi advance into the Gulf of Mexico?

State the rate of increase of the delta of the Tiber.

Show how rapid the growth of the delta of the Po has been.

38. What are the areas of the deltas of the Mississippi and of the Ganges and Brahmaputra?

Give reasons for believing that such vast deltas must be of high antiquity.

What has been observed regarding the thickness of the deposits in the delta of the Ganges?

39. Where are no deltas formed at river-mouths? Give examples.

How far is the mud of the River Amazon said to discolour the water of the Atlantic?

Lesson XXVIII.—The Frozen Waters of the Land.

Frost, Snow-Fields, Glaciers.

2. What is the effect of cold upon the density of most substances?

Would a cubic foot of pure water at 40° Fahr., or one at 60° be the heavier?

3. What happens when water as it cools reaches a temperature of 39°·1 Fahr.?

What is that temperature called, and why?

What happens to the water which is cooled below that temperature?

Why is a crust of ice formed on the surface of lakes and rivers?

How is this crust increased in thickness?

4. Over what parts of the earth's surface may these waters be frozen?

Give some historical examples of the effects of severe cold upon the waters of the land and of the sea.

5. When the frozen surface of a lake is broken up during a gale, what may be observed on shore?

What is noticed in the rivers and lakes of Canada regarding the influence of the shore surface-ice and the ice formed at the bottom (anchor-ice) upon the position of blocks of stone?

6. What happens during frost to the moisture retained in the soil and in the pores and cavities of rocks?

7. Why do water-jugs and pipes often burst in winter?

What is the extent of the expansion of water in passing into the solid state?

How does the expansive power of frost show itself on the stones of a roadway, and, when very severe, upon fences and other objects driven into the soil?

8. Why are these effects not always fully realized until after the frost is gone?

What may be observed to be the condition of soil after a severe frost has given way to thaw?

How does this condition arise?

9. Why does soil usually show these effects so well?

When do solid rocks exhibit similar effects?

How does this affect the choice of building-materials in countries where the winters are severe?

10. What are the "joints" of rocks?

What relation do these joints hold to the circulation of water?

When their inclosed water freezes how does it affect their sides?

What is the ultimate end of this process continued winter after winter?

How may these effects be detected in rugged countries?

How does this splintering action of frost affect the shapes of mountains?

11. What are snow-fields?

What is the general character of the snow-fields in the table-land of Norway?

Among rugged ranges of mountains how are the snow-fields disposed?

12. What is the condition of Greenland with regard to snow?

13. How is the indefinite heaping up of snow upon the snow-fields prevented?

What are avalanches?

What steps are taken in Alpine countries to obtain protection from avalanches?

14. What is the difference between the texture of the snow on the surface of a snow-field and that lying further down?

How does the compacted snow (*Nevé* or *Firn*) pass into clear blue ice?

Why does the snow slowly slide out of a snow-field, and what change does it undergo in the journey?

What direction must the moving mass necessarily take?

What is a glacier?

15. What analogy may be drawn between a glacier and a river with regard to the drainage of the land?

On what does the size of a glacier depend?

Give illustrations of great diversity in the size of glaciers.

How far below the snow-line does the lower glacier of Grindelwald, in the Alps, descend?

16, 17. Give a summary of the chief features of an Alpine glacier.

18. How does a glacier resemble a river with regard to motion down the valley?

What is the ascertained average rate of motion in the centre and at the sides of the Mer de Glace of Chamouni during summer and winter?

19. What are *crevasses?*

What becomes of stones and earth which may fall into crevasses?

20. What analogy in the course of a glacier can be traced to the waterfalls and rapids in that of a river?

Describe an ice-fall.

What happens to the ice after it passes an ice-fall?

To what source may every glacier and each of its tributaries be traced?

21. Show further the general analogy between the work of a river and that of a glacier.

22, 23. What is observed to be the disposition of the stones and earth upon the surface of a glacier?

To what source will one of the ridges of rubbish in the centre of a glacier always lead?

What are these ridges called?

Show how a medial moraine is formed by the union of two glaciers.

What is a terminal moraine?

24. How are the materials of moraine-ridges accumulated?

What becomes of the rubbish when it falls on the ice of a glacier?

25. Describe what is called a glacier-table,

and show how it demonstrates the melting and evaporation of the surface ice of a glacier.

How is the same lesson taught by moraine mounds?

26. What are perched blocks, and where may they be seen?

How do they prove the former greater extent of the glaciers of the Alps?

27. What lesson do these moraines and travelled blocks teach as to the work of glaciers?

Where glaciers reach the sea what further transport does the ice still sometimes perform?

28. The termination of a glacier is fixed at the point where, for the time being, the onward movement of the ice is counterbalanced by the rate of evaporation and thaw. What then is the character of the water which escapes from the end of the glacier?

When is the water muddiest?

Why cannot this mud come from the mere melting of the ice or from the brooks on either side of the valley?

29. What is to be observed regarding the surface of the rocks on the bottom and lower slopes of a glacier-valley?

How do the striæ on the rocks run in relation to the form of the valley?

To what kind of agency do they point?

30. What may be observed occasionally under the ice?

How is the smoothing and polishing of the rocks of a glacier-valley effected?

31. Show now why a glacier stream cannot fail to be always muddy.

What purpose is served by the earth and stones which fall through crevasses to the bottom of the glacier, and what change do they themselves undergo?

32. How may the importance of the eroding power of glaciers be shown in regard to the characteristic scenery of a country?

What light is thus cast upon the ancient history of Northern Europe and America?

33. What must be the ultimate effect upon a valley where glacier-erosion is long continued?

Since the erosion is not equally effective on every part of the valley-bottom, what must be the consequence of this inequality?

How is this feature of ice-work shown in the glacier districts of northern Europe and America?

LESSON XXIX. — THE SCULPTURE OF THE LAND.

1, 2. In commencing the study of the origin of the features of the surface of the land, why may we not conclude that the present land is part of the original surface of the planet?

3. What may with probability be regarded as the history of the ridges which constitute the present land of the globe?

4. Of what materials does by far the larger part of the mass of the land consist?

To what depth have these materials been accumulated?

What must have been the original position of the strata in which these materials have been arranged?

Is this original undisturbed position ever preserved?

5. What seem to have been the general effects of the earth's contraction upon the surface?

What may be inferred to have been the origin of the vast ocean-basins?

How may the subsidence of these basins be connected with elevation of land?

How on the whole may the balance of land and sea have been maintained?

6. Has the movement been always as gentle as not to disturb the original nearly horizontal arrangement of the sedimentary accumulations?

Where has the movement manifested itself otherwise?

Contrast the arrangement of the rocks on the great plains and in the mountains.

7. Make three simple diagrams (see pp. 73, 74, and 75) to show three successive stages of mountain-building, and explain each of them.

8. What lessons may be gathered from these three figures?

9. Show how the relative ages of different mountain chains may be compared.

10. How may you show that although the land owes its existence to subterranean movements, its present surface must have been shaped by other causes?

11. Enumerate the chief agents in changing the face of the land, and describe the work which they perform.

12. What kind of evidence may be gathered to show that the surface of the land is being continually eroded and altered?

13. On what do the rate and nature of these surface changes greatly depend?

What analogy may be drawn between the erosion of the land and the work of a sculptor?

14. How does the presence of joints in rocks affect the forms of cliffs and mountains?

What becomes of the blocks which fall to the ground?

How does their removal from the bottom affect the decay of the cliff?

15. Where can the influence of joints be most conspicuously seen?

Trace the action of weathering among the higher peaks of the mountains. What are aiguilles, and how are they formed?

16. What lesson as to the sculpture of the land may be learnt from the top of a high hill or mountain?

How far may a gradation be traced from a recently formed gulley to a wide and deep ravine?

Why must we conclude that the present valleys of the land are in large measure due to the erosive action of the streams which flow in them?

17. Contrast the effects of the process of sculpture among the mountains and on the plains.

Does the heightening of the plains by rivers really compensate for the excavation of the sides of the mountains? Give reasons for your answer.

18. What must be the tendency of the process of sculpture upon the surface of the land?

Besides the operations of running water over the surface, how is the margin of the land affected?

19. What must be the result of all this decay if no counteracting influence should come into play?

How are the effects of disintegration counteracted so far as to preserve a certain balance of land and sea?

What appears to be the normal system of change in the history of the land?

CHAPTER V.

LIFE.

LESSON XXX.—THE GEOGRAPHICAL DISTRIBUTION OF PLANTS AND ANIMALS.

1. WHAT is meant by Biology?

2. Mention some of the more important branches into which Biological science is divided.

3. How must plants and animals be studied from the point of view of physical geography?

4. Illustrate from the equatorial regions how distinct are the plants and animals of different large regions of the earth's surface.

5. Enumerate some characteristic forms of vegetation in the temperate zone.

Mention the names of a few distinctive animals of the same zone.

6. What general remark may be made regarding the life of the Arctic and Polar regions?

Briefly describe the vegetation of these regions.

What peculiar forms of animal life are there met with?

7. What conclusion as to the distribution of

life must be drawn from the abundance and variety of plants and animals in tropical regions and their disappearance towards the poles?

8. Were temperature the sole cause at work in regulating the distribution of life, what ought to be the character of that distribution?

Explain the terms *Fauna* and *Flora*.

Do similar conditions of soil, climate, and exposure afford the same forms of animal and vegetable life in the same latitudes on different sides of the globe?

What is the true state of the case?

Show the contrast between the Old and New Worlds by some examples of the way in which corresponding animals differ in the two hemispheres.

9. What must first be done in the investigation of the causes which have led to the present arrangement of plants and animals upon the globe?

What has been the result of this inquiry?

10. Define the limits of the Palæarctic region.

Describe the character of the vegetation in the Arctic parts of this region.

Where do pine-trees begin to appear, and where do they abound?

Describe the vegetation south of the zone of pine forests.

What is the character of the vegetation in those more southern tracts, where the mean annual temperature exceeds 60° Fahr.?

11. Enumerate some of the more typical arctic animals.

To what forms of life do these give place in the more temperate parts of the Palæarctic region?

What animal characterizes the southern limits of this region?

12. Define the area of the Ethiopian region.

What are the more marked features of the vegetation of West Africa, south from the Great Sahara Desert?

What is the character of the vegetation in the eastern and in the southern tracts?

13. What familiar animals are absent from the Ethiopian region?

Enumerate some of the characteristic animals of this region.

14. Define the limits of the Oriental region.

Describe the general aspect of the vegetation of this region.

15. Enumerate some of the more distinctive animals.

16. Define the area of the Australian region.

Why are the contrasts of climate striking in Australia?

What is the character of the flora of the dry and warm tracts of Australia?

What is remarked about the vegetation in the north of Australia?

How is the flora of the southern part of that country distinguished?

What is the character of the flora of New Zealand?

What characteristic plants are found throughout the scattered Pacific Islands?

17. What general remark may be made about the Australian fauna?

Mention some widespread animals which are wanting there?

Enumerate some typical Australian animals.

18. Define the area of the Neotropical region.

What is the character of the flora of the lower grounds within the tropics?

What are the "llanos" of the Orinoco?

What are the "pampas" of La Plata?

Above the plains the lower mountain-slopes have a distinctive vegetation. Enumerate some of its most marked forms.

What may be remarked regarding the flora of the more elevated tracts?

19. What general remark may be made about the fauna of this, as compared with those of other regions?

Enumerate some of its most peculiar forms.

20. Define the area and describe the form of the Nearctic region.

Is the isolation of this large mass of land accompanied with any peculiarity in the general character of the flora and fauna?

Is the difference between the flora and fauna of the Nearctic and Palæarctic regions as great as between those of the Ethiopian and Neotropical regions?

What are the respective characters of the vegetation in the extreme northern and extreme southern parts of the Nearctic region?

Mention some features of the vegetation in California and Oregon; in the basin of the Mississippi; and over the British possessions.

21. How does the fauna of this region vary?

Mention some characteristic animals in the north.

Enumerate others which take their place farther south.

LESSON XXXI.—THE DIFFUSION OF PLANTS AND ANIMALS.

Climate.—Migration and Transport.—Changes of Land and Sea.

1, 2. What kind of evidence may be cited to show that the present species of plants and animals have not always existed?

3. What three chief influences appear to have been at work in the present grouping of plants and animals over the globe?

1.—*Climate.*

4. What is included under the term "climate"?

Besides a knowledge of the distribution of temperature, what further information is needed to enable us to realize what the climate of a place must be?

5. Name the influences which chiefly regulate the climate of a district.

6. What is the main element in the determination of climate?

Where are the warmest climates to be found, and why do they occur there?

Why do the climates become cooler as we recede towards the poles?

Where do the coldest climates occur?

7. How would the climates of the globe be arranged if the earth's surface were all land or all water?

What prevents this arrangement of climates?

Nevertheless, though the climates do not strictly follow the parallels of latitude, they are so arranged as to follow each other in successive bands from the equator to the poles. How is this shown by the lateness or earliness of vegetation?

Illustrate this subject by some examples from the vegetation of Europe.

What is the meaning of such phrases as "an Arctic vegetation," "a temperate flora," "a tropical fauna"?

9. Show how the climates of Central Europe and parts of the United States, though resembling each other, are distinguished by very different groups of animals.

Draw a similar contrast between central South America and corresponding latitudes in Africa.

Passing to Australia, what further contrast is found?

What general deduction may be made from the facts stated in paras. 4—10 of the present lesson?

10. What is the broad difference between sea-climates and land-climates, and on what does it depend?

What change is observable in climate in proportion as places recede inland from the sea?

Define an insular or oceanic climate.

Define a continental climate.

11. How are these variations shown by the vegetation of the Atlantic border and central parts of Europe?

12. Give a further illustration of the contrast between an insular and oceanic climate.

13. What is commonly assumed to be the rate of fall of the thermometer as we ascend above the sea-level?

How should this fall affect the vegetation of the lower grounds?

How is the fall of temperature with elevation shown by changes in the character of the vegetation of the mountains?

Describe the three sections in Fig. 78.

Illustrate the influence of height above the sea on the distribution of animals.

14. Why are the winds from a cold region cold, and from a warm region warm?

What is the usual character of winds from the sea and from the land respectively?

What difference may be noted between sea-breezes and land-breezes in regard to variations of temperature?

Explain the reason of this difference.

Why are winds often rainy which come from lower to higher latitudes, or from warm to cool climates, while, blowing from higher to lower latitudes or from cold to warm regions, they are dry?

15. Where is the influence of prevailing winds upon the climate of a place particularly well-marked?

Give an example of this influence.

16. How does the moisture of the climate affect vegetation?

Give an illustration of this influence.

17. Show how the moisture of the climate tells indirectly upon the animal population of a region.

18. Among local causes affecting climate the character of the soil is of importance. What influence then has marshy or wet ground upon mean temperature, and why?

How does the drainage of such land affect temperature?

Mention an ascertained effect of drainage in some parts of Britain.

What is the character of the climate where the ground is covered with wide wastes of sand? Explain the cause of this.

19. What influence is exerted on climate by a surface of vegetation?

20. How do lakes affect the climate of the districts surrounding them?

21. What is the nature of the influence exerted upon climate by the neighbourhood of high ground?

22. Are the boundaries between botanical and zoological provinces always marked by contrasts of climate?

Are similar climates always accompanied by similar assemblages of plants and animals?

Show by some examples that there is an unfitness in many climates for the spread of species of plants and animals which have never lived in them.

23. What conclusion may be drawn from the facts stated in this section of the present lesson?

2. *Migration and Transport.*

24. Can the present arrangement of plants and animals be explained on the supposition that all the species first appeared in one region or continent and then spread gradually over the globe?

25. There can be no doubt, however, that many species both of plants and animals have great powers of diffusion. Show how this may be illustrated in various ways in the case of seeds.

Mention some reasons which go to show that some of these ways of transport have probably contributed very largely to the distribution of the present floras of the globe.

26. Illustrate some of the various ways in which animals may have been carried from one country to another.

Show how limited and exceptional these means of transport are.

27. Most animals remain within well-defined limits. Give examples of others which migrate to great distances.

28. Show why it is that the vast majority of animals are confined within and cannot stray beyond their own districts.

29. Describe some of the physical barriers which prevent the dispersion even of animals which can endure many varieties of climate.

30. On the supposition that some few animals succeed in surmounting one of these natural

barriers, what conditions must they find in their new abode to allow of their becoming naturalized there?

What would be their position in reference to other animals already long established in the country?

31. From the consideration that the vast majority of plants and animals are hemmed in by natural barriers so as to be confined to their own provinces, what conclusion must be drawn as to the origin of the present floras and faunas of the earth's surface?

How is it known that each great biological province has not always been as it is now, but has gone through many changes of physical geography, and has had many successive races of plants and animals, of which the present species are the lineal descendants?

3. *Changes of Land and Sea and of Climate.*

32, 33. Changes of land to sea and sea to land, the elevation of mountains, and the formation of valleys, lakes, and plains, could not take place without powerfully affecting the distribution of plants and animals. To illustrate the nature of this influence and the way in which the present flora and fauna may be made to throw light upon the past history of a country, let us take as an illustration the flora of Western Europe. What general remark may be made regarding the vegetation of the plains of Central Europe up to the shores of the Baltic?

Since the same plants are found throughout Britain, what point do they establish in the history of the physical geography of that part of Europe?

34. What change in the vegetation is to be observed as we ascend any of the larger hills in Britain, or the Alps, or Pyrenees?

Is this change local or general? Show how it may be noted in Britain.

35. Why can we not believe this vegetation merely to be one peculiar to elevated ground?

What is to be noted regarding the position of these plants in reference to the sea-level in different parts of Europe?

What must be inferred as to their real home?

36. Why is it inconceivable that Arctic plants should force their way across the European plain, as that plain is at present, with its existing vegetation?

Under what circumstances might they advance southwards?

37. What evidence may be adduced to show that these circumstances did really once exist?

38. What further and physical evidence exists to prove a former extension of Arctic cold over Europe?

39. If, then, the Arctic plants during that cold period spread over central and western Europe, how have they come to occupy now their present positions?

40. Can any similar changes be cited from North America?

41. State briefly how this illustration indicates the complex nature of the problem of accounting for the existence and differences of the biological regions.

What may be expected from the further investigation of this subject in regard to the history of the earth's surface?

42. State in fine some of the leading ideas which science seeks to fulfil.

THE END.

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